This TYPE I report is submitted for ERTS Contract No. S-70251-AG for the period December 19, 1972 through February 19, 1973.

Title of Investigation: Reflectance of Vegetation, Soil, and Water

GSFC ID: AG 339

Objective of the Contract:

The objective of this proposal is to develop an operational system of ERTS data analysis for the needs of the Department of Agriculture. The seasonal changes in reflectance of various soils and of various crops grown in the Rio Grande Valley will be studied utilizing satellite, ground, and aircraft spectral data. In particular, comparisons will be made between ERTS data and predictions from already developed analytical models describing the interaction of light with plant canopies; discrimination of specific crop and soil conditions of interest will be attempted; and chlorophyll content of plant leaves will be correlated with reflectance in the visible part of the spectrum. (See also Attachment A to the Contract.)

Chronology of Important Events Associated With the Contract:

June 19, 1972 -- Contract awarded
July 26, 1972 -- Aircraft (C-130B) support Mission 207 was flown
Aug. 25, 1972 -- Received first ERTS-1 photoproducts (orbit 27)
Oct. 5, 1972 -- Received photoproducts from Mission 207
Dec. 6, 1972 -- Received 25 digital magnetic tapes from Mission 207
Oct. - Nov. 19, 1972 -- Was too cloudy on scenes of test site during this time period to request CCT.
Dec. 16, 1972 -- First orbit (No. 2035) of useable data from test site
Dec. 18, 1972 -- Placed phone order for bulk digital tapes
Jan. 21, 1973 -- Simultaneous ERTS-1 (orbit #2537) and C-130B aircraft support (Mission 226) coverage under clear conditions
Feb. 20, 1973 -- Ordered bulk CCT from Jan. 21 overpass
Mar. 1 and 5, 1973 -- Received partial shipments of Mission 226 photoproducts.
Mar. 9, 1973--Received CCT from orbit 2035.

Table 1 lists ERTS photoproducts received during this reporting period along with identifying, quality, and other information.

Statement of Problems in the Report Period:

CCT from the aircraft Mission 207 were received in December. These tapes have been studied, but those efforts have been hampered by the lack of an effective users' manual describing the data furnished from the C-130B aircraft. Dr. Leamer and Mr. Richardson of our staff visited the LBJ Space Center February 5-7 and discussed radiometric calibration, sources of noise, and least significant bit problems in the data. Mr. Richardson and Mr. Gautreaux also attended the MSS Status Review Conference held Feb. 26-27 at NASA, Houston, where the same things were again discussed.

Table 1. ERTS photoproducts received during the Oct. 19, 1972 to Feb. 19, 1973 period along with identifying, quality, and other information.

File No.	Orbited Area & PP	Cloud Cover	Orbit No.	Orbit Date	HR	Chan	Qual	Material received & Date received			
								70mm Neg	70mm Pos	9.5" Pos	9.5" Pr
								10/19/72		10/19/72	
41	LRGV	40%	529	8/30/72	1038-16314	4	G	x		x	
42	25.970N					5	G	x		x	
43	97.952W					6	G	x		x	
44						7	G	x		x	
									10/24/72	10/24/72	
45	Anzalduas	0%	543	8/31/72	1039-16370	4	G		x	x	
46	& North					5	G		x	x	
47	27.375N					6	G		x	x	
48	98.986W					7	G		x	x	
49	N. Mexico	0%	543	8/31/72	1039-16373	4	G		x	x	
50	25.912N					5	G		x	x	
51	99.374W					6	G		x	x	
52						7	G		x	x	
								10/24/72		10/24/72	
53	CorpChri	60%	780	9/17/72	1056-16312	4	G	x		x	
54	27.320N					5	G	x		x	
55	97.497W					6	G	x		x	
56						7	G	x		x	
57	LRGV & Mex	50%	780	9/17/72	1056-16314	4	G	x		x	
58	25.897N					5	G	x		x	
59	97.877W					6	G	x		x	
60						7	G	x		x	
								11/8/72		11/13/72	
61	Anzalduas	40%	1045	10/6/72	1075-16371	4	G	x		x	
62	& North					5	G	x		x	
63	27.459N					6	G	x		x	
64	98.930W					7	G	x		x	
65	LRGV & Mex	40%	1045	10/6/72	1075-16373	4	G	x		x	
66	26.017N					5	G	x		x	
67	99.322W					6	G	x		x	
68						7	G	x		x	
								11/17/72		11/17/72	
69	CorpChri	10%	1282	10/23/72	1092-16314	4	G	x		x	
70	27.348N					5	G	x		x	
71	97.552W					6	G	x		x	
72						7	G	x		x	
73	Weslaco	60%	1282	10/23/72	1092-16321	4	G	x		x	
74	25.916N					5	G	x		x	
75	97.948W					6	G	x		x	
76						7	G	x		x	

Table F. Continued

File No.	Orbited Area & PP	Cloud Cover	Orbit No.	Orbit Date	HR	Chan	Qual	Material received & Date received: 70mm Neg	70mm Pos	9.5" Pos	9.5" Pr
								12/11/72		12/11/72	
77	Corp Chri	10%	1533	11/10/72	1110-16320	4	G	x		x	
78	27.289N					5	G	x		x	
79	97.624W					6	G	x		x	
80						7	G	x		x	
81	E Cam Co	10%	1533	11/10/72	1110-16322	4	G	x		x	
82	N Mex, RGV					5	G	x		x	
83	25.847N					6	G	x		x	
84	98.015W					7	G	x		x	
								1/22/73		1/22/73	2/5/73
85	Corp Chri	20%	2035	12/16/72	1146-16320	4	G	x		x	
86	27.296N					5	G	x		x	
87	97.603W					6	G	x		x	
88						7	G	x		x	
89	E Cam Co	30%	2035	12/16/72	1146-16323	4	P	x		x	
90	N Mex, RGV					5	G	x		x	x
91	25.874N					6	G	x		x	
92	98.007W					7	G	x		x	
								2/16/73		2/8/73	
93	Corp Chri	20%	2286	1/3/73	1164-16315	4	G	x		x	
94	27.332N					5	G	x		x	
95	97.517W					6	G	x		x	
96						7	G	x		x	
97	E Cam Co	40%	2286	1/3/73	1164-16321	4	G	x		x	
98	N Mex, RGV 25.886N					5	G	x		x	
99	97.920W					6	G	x		x	
100						7	G	x		x	

The other situation encountered was the lack of ERTS-1 CCT data prior to the ERTS-1 Symposium. We could not, therefore, contribute to that Symposium.

There has been a delay in awarding the contracts to update the computer CPU speed from 4 μsec to 2 μsec, and to convert from 1810 disc drives to 2311 disc drives because of internally conflicting statements that forced re-issuance. The solicitation responses were opened Mar. 13; the work will now proceed and it is anticipated it will be completed this fiscal year at a cost of $41,198.

Summary of Work Performed this Reporting Period:

Aircraft Data

Aircraft data have been requested to obtain spectral information not available in ERTS-1 data, to obtain data of finer resolution to compare discrimination accuracies of ERTS-1 data against, to document ground conditions, and to develop procedures to assign every resolution element in any scene to some classification category (Procedures previously used at Weslaco have been based on mean values for each field rather than on each resolution element).

Aircraft support has been adequate. The first aircraft support data was flown July 26 and CCT were delivered Dec. 6, which is satisfactory. However, the increasing data backlog may cause this time lag to increase. We believe it should never be greater than 6 months. We need a user's manual, however, and feedback from NASA Houston (either by inflight operators of the instruments or ground data facility personnel) on quality of the data as affected by inflight or ground data handling systems.

The CCT furnished from the Mission 207 CCT were studied to (a) study the general quality of the MSS data, (b) determine the spectral signature of various crop, soil, water, and man-made features, (c) determine the optimal MSS channels for one representative scene, and (d) measure the recognition accuracy of discrimination using the MSS data. A brief summary of these studies follows: The standard errors of estimate for each of the 24 channels for a very uniform surface, a water reservoir,were used as an indicator of noise. By this criterion channels 22, 20, 15 and 21 were of low quality. More odd than even value digital counts were found in all channels and the conclusion was reached that the data are really 7 bit precision. As expected the signatures for diverse areas such as water, highway, roof tops and bare soil differed from those of the vegetal categories. Among the vegetal categories, sugarcane and cotton had distinctive signatures that distinguished them from grass and citrus. An optimum channel selection program selected channels 7, 8, 3, and 18 as optimal for distinguishing 7 vegetation categories: Stoneville 213 cotton, Anton SP-21 cotton, Valencia orange, Red blush grapefruit, sugarcane, coast-cross 1 bermudagrass and African stargrass. These same channels also distinguished the nonvegetal categories satisfactorily.

Classification accuracies improved to about 81% when the intra plant genera categories (such as the two cotton varieties) were combined into one. Most misidentifications were among vegetation categories. Acreage estimates of the categories with few misidentifications from the number of resolution elements in the category agreed well with known field sizes and acreages estimated from aerial photographs.

A full report of these studies is in preparation; it will be included in the next TYPE II report.

Ground Truth

As mentioned in the last TYPE II report, about 1500 fields are groundtruthed to obtain valid statistical estimates of crop and soil condition category acreages in the test county (Hidalgo) from interpenetrating samples. The fields have now been groundtruthed 9 times. The main purpose for collecting such a complete set of records is to have a base to compare the reliability and accuracy of the ERTS-1 CCT data discrimination results against.

During this reporting period we have made significant progress in determining: (1) the distribution of field sizes in the county, (2) the farmable acres versus the total acres in the sample segments, and (3) statistical estimates of the acreage of the classification categories carrots, cabbage, onions, cotton, sugarcane, citrus, bare soil (and dry debris), and rangeland on various dates.

Table 2 is a summary of the distribution of the size and farmable acreage of fields by interpenetrating samples 1000, 2000, ..., 8000. The field size groupings, in acres, are: 0 to 10, 10 to 20, 20 to 30, 30 to 40, 40 to 100 and >100. The summary reveals, for example, that 22.48% of the acreage is in fields 20 acres or smaller in size. The percentage of the fields smaller than 10 acres is 35.1% and between 10 and 20 acres in size is 26.5%--or 61.6% of the fields are smaller than 20 acres. Difficulty discriminating these small fields with data of the resolution of ERTS-1 is anticipated. At the other extreme, although only 3.9% of the fields are larger than 100 acres they constitute 29.37% of the land area. (Note: The total number of fields in this printout is 1666. This number varies throughout the year as farmed land is subdivided into fields slightly differently from growing season to growing season; but for any one ground truth set the same land area is represented only once.)

Table 2. Summary of number of fields and acreage by interpenetrating sample and by field size categories.

Interpenetrating sample	FIELD SIZE (ACRES) 0-10	10-20	20-30	30-40	40-100	Over 100	Total Fields
	Number of Fields						
1000	124	76	59	27	43	13	342
2000	119	97	51	26	47	18	358
3000	143	102	48	27	39	13	372
4000	163	120	52	40	33	18	426
5000	8	13	6	4	5	1	37
6000	5	9	8	5	9	2	38
7000	21	15	6	13	6	0	61
8000	2	10	4	7	9	0	32
Total Fields	585	442	234	149	191	65	1666
% of Fields	35.11	26.53	14.04	8.94	11.46	3.90	99.98
	Number of Acres						Total Acres
1000	781.85	1128.10	1416.11	953.77	2666.20	2817.27	9,763.34
2000	726.27	1404.00	1261.33	894.31	2607.57	3902.44	10,795.96
3000	844.68	1543.49	1137.51	952.41	2263.53	2552.22	9,293.88
4000	1051.11	1714.77	1266.72	1369.98	1753.19	3584.67	10,740.47
5000	44.29	202.89	156.50	146.60	309.70	151.90	1,011.89
6000	36.66	139.89	195.19	186.19	472.20	231.26	1,261.43
7000	144.59	205.59	147.09	450.19	303.57	0.00	1,251.06
8000	16.60	153.09	95.79	242.26	447.99	0.00	955.75
Total Acres	3646.10	6491.87	5676.29	5195.76	10823.99	13239.79	45,073.70
% of Acreage	8.08	14.40	12.59	11.52	24.01	29.37	99.97

Interpretation of Photo Products

Various approaches are being tried to color composite the black-and-white photoproducts to determine whether the more subtle features such as soil patterns can be enhanced. One has been to project 70-mm positives produced from the 70-mm negatives onto a screen by three lantern slide projectors and vary the color filters in the light beam. Each lantern slide projector is also equipped with a rheostat so that variable voltage can be applied to the projector lamps.

Another procedure used has been to dye positive transparencies of each of the four bands red, green, blue, and yellow. These dyed transparencies can be projected onto a screen in various combinations using the three lantern slide projectors. Inclusion of the filter in the image was reasoned to result in a sharper image than if the filter is placed in front of the projector lens, as for the first approach mentioned.

Some general features can be seen to possess interesting color tone differences. We have provided ability to rotate the images slightly (tilt lantern slide projectors) in order to better register the various bands over the whole scene. Misregistration distracts from the synoptic view the ERTS scenes possess and forces focusing only portions of scenes.

Significant Results and Practical Applications:

The ability to read the 24-channel MSS CCT tapes, select specified agricultural land use areas from the CCT, and perform multivariate statistical and pattern recognition analyses has been demonstrated.

There are problems with noise and precision in the 24-channel MSS data that degrade their quality. Studies of the least significant bit (LSB) indicate more odd than even count values in all channels. For the 3,000 ft AGL data, reflectance was also a function of scan angle.

The 5 optimum channels chosen for classifying an agricultural scene were, in the order of their selection the far red visible, short reflective IR, visible blue, thermal infrared, and ultraviolet portions of the electromagnetic spectrum, respectively. Although chosen by a training set containing only vegetal categories, the optimum 4 channels discriminated pavement, water, bare soil, and building roofs, as well as the vegetal categories. Among the vegetal categories, sugarcane and cotton had distinctive signatures that distinguished them from grass and citrus.

Acreages estimated spectrally by the computer for the test scene were acceptably close to acreages estimated from aerial photographs for cotton, sugarcane, and water. Many nonfarmable land resolution elements representing drainage ditch, field road, and highway right-of-way as well as Farm headquarters area fell into the grass, bare soil plus weeds, and citrus categories and lessened the accuracy of the farmable acreage estimates in these categories.

The expertise developed using the 24-channel data will be applied to the ERTS-1 data.

Publications:

None.

Recommendations Concerning Changes in Operations, Additional Investigations Efforts, and Effort/Results as Related to the ERTS System:

See TYPE I report for the June 19 through October 19 period.

Additionally, an aircraft data users' manual is recommended.

Changes in Standing Order Forms:

None.

ERTS Image Descriptor Form:

See attached, completed form.

Changes in Retrospective Data Requests:

None.

Planned Work for the Next Reporting Period:

Priority effort will be placed on (a) systematic analysis of the Dec. 16 overpass ERTS-1 MSS CCT, (b) ground-truthing for the current warm growing season, and (c) implementing the leaf area index (LAI) determinations (a cold, wet January and February delayed the planting of corn and other crops).

ERTS IMAGE DESCRIPTOR FORM

PRINCIPAL INVESTIGATOR:
~~USERNAME~~ Craig L. Wiegand DATE March 30, 1973
USER ID AG 339
AGENCY USDA-ARS

PRODUCT ID (Include Band and Product)	Frequently Used Descriptors *				DESCRIPTORS
	COAST	CROPLAND	RANGELAND	LAKE	
1038-16314-5	EEO				Estuary, Cumulus
1039-16370-5			X	X	Hydrology
1039-16373-5			X	X	---
1056-16312-5	X				Cumulus, Stratus
1056-16314-5	X				Cumulus, Stratus
1075-16371-5			X	X	Cumulus
1075-16373-5			X	X	Cumulus
1092-16314-5	X	X	X		City
1092-16321-5		X			Clouds
1110-16320-5	X				Clouds
1110-16322-5	X				Clouds
1146-16320-5	X	X	X		Clouds
1146-16323-5	X	X	X		Clouds
1164-16315-5	X				Clouds
1164-16321-5					Clouds

*For Descriptors which will occur frequently, write the descriptor terms in these column heading spaces now and use a check (✓) mark in the appropriate ID lines. (For other descriptors, write the term under the DESCRIPTORS column).

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